SPATIAL LAYOUT DESIGN FACTORS DURING PANIC SITUATIONS

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ABSTRACT. Crowd management is the human-traffic problem-solving for crowd control to manage the crowd activities by monitoring, simulating and designing model. This concept paper is to discuss on the crowd management and discover the major contributing factors that lead towards casualties during panic situation. Crowd management activity has a close relation with spatial management that gives a high impact towards the movement of pedestrian during a certain situation and space. Hence, this concept paper provides a validation on effect of the behavior reflection based on the spatial layout design during panic situation.

Keywords: crowd management, spatial layout design, evacuation, pedestrian simulation

INTRODUCTION

Nowadays, there are a lot of natures or man-made emergency situations that will contribute towards panic crowd. Panic crowd is the panic behavior reflection where the pedestrian (crowd) will have a great shock and will response with drastic reaction towards panic situation to save or avoid the physical contact or any harm towards them. The panic situations can be define as a situation that lead towards crowd's chaos such as loud bombing sound, the sound of fire alarm, smell or heat from large fire combustion, earthquake and etc. These panic situations will create stress and panic impact by crying, yelling, pushing and shoving that lead to the anxiety of pedestrians which will cause numbers of injuries and death (Lu et al., 2017).

There are several cases happened due to the lack of crowd management factors such as happened in Station Nightclub Fire in Rhode Island in 2003, Address Downtown Hotel in Dubai during new year's eve in 2015 and Mina stampede in Mecca during hajj pilgrims in 2015 (Lu et al., 2017; Yamin, Al-Ahmadi, & Muhammad, 2016). These panic situations can be overcome with crowd management models, to control the crowd for evacuation process which will result the lower congestion level and lower percentage of fatal incidents (Zong & Jiang, 2016). Figure 1 shows the general overview of crowd management.
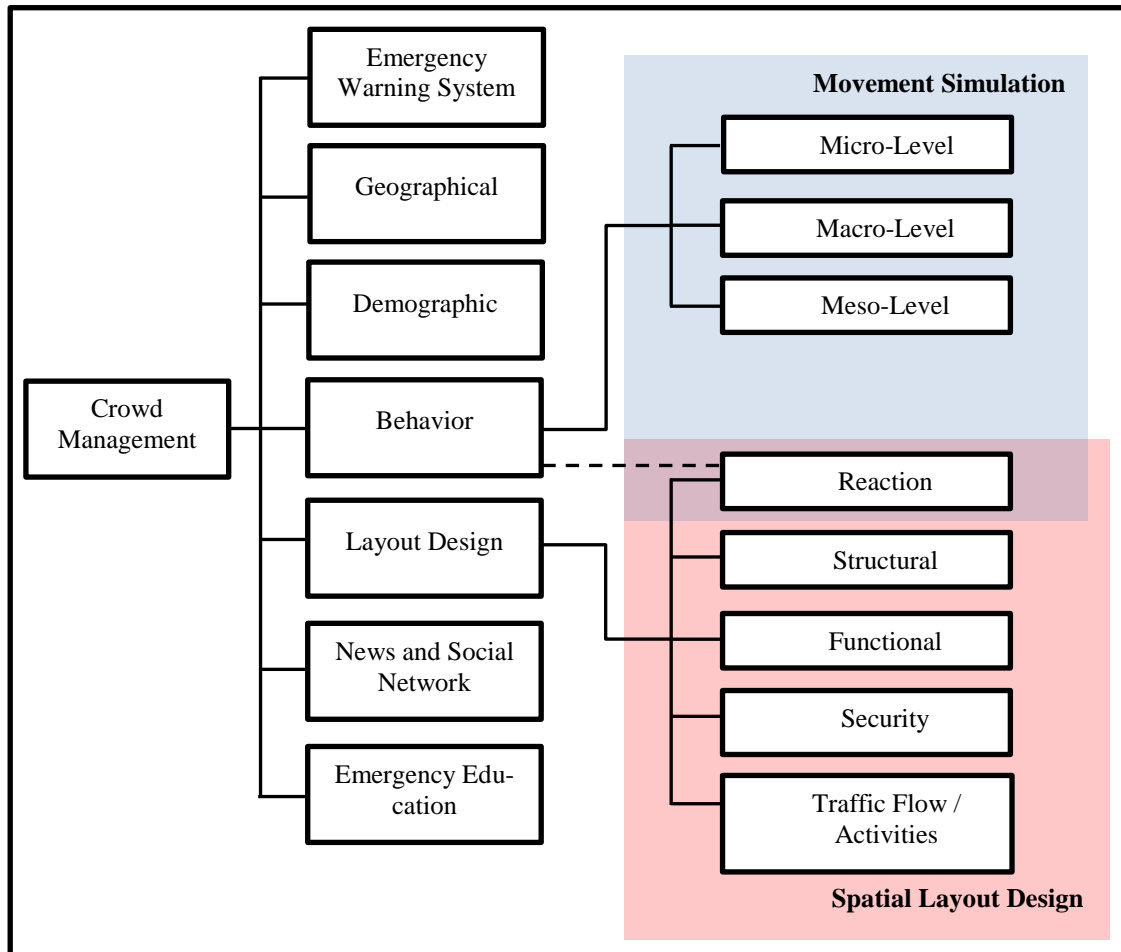
Figure 1. Overview of Crowd Management.

Based on Figure 1, crowd management is divided into several aspects such as entity (emergency education and behavior), physical (emergency warning system and layout design), environmental settings (geographical and demographic) and communication (news and social network) (Huixian & Shaoping, 2016; Sime, 1995).

Environment setting plays a great impact on crowd management for safety purposes due to the catastrophic disaster which influence by the geographical location and demographic culture. Natural disasters such as flooding, tsunamis, earthquake, drought and typhoon are based on the geographical location that will influence the crowd management systems of the certain space. Whereas, demographic culture is the social factor of the crowd management which includes the terrorism, nuclear power plant accidents, fire and transportation malfunctions also had become the catalyst for the crowd management model factors for the higher level of crowd control (Huixian & Shaoping, 2016).

Due to the environment setting factors, initially, the emergency warning system had been introduced to manage the crowd notification and movement during panic situation for evacuation. There are a lot of effective emergency warning systems available such as siren, announcement, lighting direction, fire detector and etc. However, poor communication and limited information broadcasting also will result a fatal incident during the panic situation (Sime, 1995). For example, the South Korea Sewol Sunken Ferry Accident in April 2014 was be-

lieved that the numbers of death of the passengers can be reduce if the passengers had been warned and more evacuation procedures been implemented (Dostal, Kim, & Ringstad, 2014; Sime, 1995).

Nowadays, media had played a great effect on influencing the society. However, the evolution of the current events broadcasting had grown from newspaper printing to news broadcasting and to-date, the electronic broadcasting. The social media is the new evolution of news transmission and had become the most tremendous growth of non-boundary space that also was exploited for broadcasting the emergency warning situations and disasters' news (Olteanu, Vieweg, & Castillo, 2015; Yin, Lampert, Cameron, Robinson, & Power, 2012). This communication medium had become a hot debate approach for crowd management due to the increasing of nowadays' technology on the communication devices that provide the mobility support and become the basic needs of human being. The crowd can be manage via social media by the distribution of the data capture, impact assessment, topic clustering and geotagging (Yin et al., 2012). This new distribution will helps the society to have access on the current situation while increasing their level of awareness especially during panic situations.

Safety education was practiced and taught as early as kindergarten that includes the awareness and the reaction during the panic situation. Nevertheless, almost all of the organizations also have their own emergency drill exercise to educate their employee to evacuate correctly based on the building's special layout and design during the real emergency situation. This emergency education has really gives a great impact on crowd management as the pedestrian had been groom with the safety and survivor instinct that will lessen the fatal result of any incident.

Based on (Lu et al., 2017), the first survival instinct during the panic situation will be; 1) finding the local information, 2) considering fewer possible routes of escape, and 3) finding the shortest path out of the affected area. However, based on research by Sime (1995), panic situation can lead to the irrational judgement and abrupt reaction that influence the crowd behavior, including the pedestrian that well familiar with the environment settings or aware of the safety procedures.

Figure 1 had shown the classification of crowd behavior for crowd control based on the three grouping level. The micro-level crowd is the homogenous entity-based approach which usually spotted at the office blocks, organization or business space which the pedestrian is a separate entity with their own destination and purposes that lead towards their individual decision making in evacuation during panic situation. The macro-level crowd is the heterogeneous crowd-based of pedestrian that move in a high density of entities with average flow of movement. This macro-level behavior will cause the increment of evacuation time compare to micro level due to the large number of attached pedestrian moving at a time (Huixian & Shaoping, 2016). This level will have higher fatal risk compare to the micro level behavior.

The meso-level crowd is the familiarity or team level of pedestrian group's movement (herding). This heterogeneous crowd-based movement is an agent-based approach that responsible to make a group's decision making while the followers will have full believe on the agent's judgement and movement. Meso-level has higher level of fatal risk above all of crowd behavior level due to the great responsibility and emotion attachment while the agent make a right decision during panic situation and also have a high density of entities with a slow movement compare to macro-level crowd. The level of the crowd can be shifted from one level to another based on the environment they are stranded in and influence by their nature behavior. Based on research by (Lu et al., 2017), the pedestrian anxiety have a great affect during panic situation when the pedestrian will shift their entity-based approach decision

mechanism into the heterogeneous entities or agent-based approach, following their instinct to be in a group to move.

The crowd movement can be shaped based on the spatial layout design. This spatial design is to find the best physical arrangement that satisfies a diverse set of limitation of pedestrian movement. The limitation will include the functionality, cost, management and etc. Based on research made by (Sime, 1995), there is a strong relation between spatial layout design, communication technology, crowd movement and crowd behavior. Each of these factors is able to affect the percentage of pedestrian's death during evacuation for panic situation (Sime, 1995).

This paper had focused on the discussion of spatial layout design factors for managing the crowd movement.

SPATIAL LAYOUT DESIGN FACTORS

The crowd management solely is not applicable for all situations due to the structural and functional needs. Hence, the best planning for the crowd management will be associated with the specific spatial environment management that does include the structural, functional and mechanical elements.

Spatial layout design is a physical arrangement of a selected space to complete or assist human activities. Based on Figure 1, spatial layout design has several factors such as; traffic activities, security, functionality, structural architecture and reaction.

The layout design of a space can influence the movement of pedestrian in both of normal and panic situation. The spatial layout design of normal situation usually demands the width and strategic location of ingress and egress to maintain the flow of the pedestrian's traffic and avoid bottleneck (Sime, 1995). This traffic flow is important to ease the traffic activities and avoid crowd's pushing behavior that can initiate the stampede incident during non-panic situation. Spatial layout design also being implemented for the business and exhibition purposes to ensure the pedestrian able view the overall corner of the space (Wineman & Peponis, 2010). The normal situation spatial layout design can be enhanced for the panic situation management.

There are a lot of research on spatial evacuation planning and safety design to reduce the serious injuries and death during panic situation (Huixian & Shaoping, 2016; Tcheukam, Djehiche, & Tembine, 2016; Zong & Jiang, 2016). The safety design includes the warning system, lighting assistance for direction and etc. However, this safety design lean more towards the process of survival after the panic situation happened.

Functionality based of spatial layout design able to reduce the cost of facilities usage while increase the function scalability. This spatial layout design usually proposed for the limited access of space or object or equipment that needs to be shared, access and operate by different entities. This functionality spatial layout design will build a reasonable, practical, convenient and workable space for the specific operation to be performed (Zhu, Zhu, & Liao, 2009). In this research, instead of dealing with the relationship between the pedestrian and the specific function of the space, it is important that for the researchers to focus on the structural architecture.

Structural architecture is the physical arrangement in a space based on the requirement and architecture design paradigm. However, this layout design will not create an opportunity for the pedestrian to successfully save themselves during the panic situation. This structural architecture can contribute towards the evacuation process of panic situation by structuring the design based on the spatial layout design simulation that considering the reaction and behavior of the pedestrian (Huixian & Shaoping, 2016; Lu et al., 2017; Sime, 1995).

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SPATIAL LAYOUT DESIGN: BEHAVIOR AND SIMULATION

Spatial layout design is able to shape the human activities and behavior. This behavior is close to the human reaction whenever they face danger in certain situation. This statement was supported by Lewin's Equation in human behavior;

$$B = f(P,E) \qquad (1)$$

Equation 1. Lewin's Equation where B is the behavior or reaction, P is the pedestrian and E is the environment.

Behavior is the function of the pedestrian in their environment (Kihlstrom, 2013). This equation had shown that the environment can shaped the behavior of pedestrian and not the personality of the pedestrian. Based on (Kihlstrom, 2013), the Lewin's Equation is made for human's psychological reaction towards the social and culture forces. However, in this research, the environment also can be interpreted as the physical environments that force the behavior of human. Hence, the spatial layout of the environment (space) also plays great effect on the human's psychological reactions which includes the behavior of being panic during evacuation. This spatial layout design based on the behavior of pedestrian can be simulate by integrating the body and brain reflection and the desire direction of movement as a reflection during panic situation (Huixian & Shaoping, 2016; Sime, 1995). The simulation of pedestrian movement is a well-known approach in nowadays architectural design process to re-enact the real situation of the pedestrian to reach the real-life level of activities.

Based on (Sime, 1995), the real-time (T) of the pedestrian to escape is not start from the standing point to the egress point, $T = t_2$ but, rather it will include the decision-making time that is;

$$T = t_1 \, (\textit{decision-making to move}) + t_2 \, (\textit{standing point to egress}) \qquad (2)$$

Equation 2. Time taken for evacuation process where T is the real-time, t_1 is the time for decision-making on the escape route and t_2 is the time for pedestrian to move from the standing point to the decided egress.

Hence, to achieve the real-time evacuation, the almost real simulation is needed with the inclusion of movement and behavior factors.

CONCLUSION

Spatial layout design is a subset of crowd management that becomes one of the main factors in planning and designing a space. With the assistance of psychological of the pedestrian, the reflection behavior of the pedestrian during the panic situation becomes the focal point of designing a real-life simulation of pedestrian movement. This enhancement of pedestrian movement will able to re-create and re-design a better spatial layout. Hence, a better spatial layout design indeed can help the pedestrian to evacuate efficiently during panic situation with various kinds of behavior and extra reaction.

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